

**EXHIBIT A**



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DECLARATION

Re: US patent application 09/857606

I, Magnus Limbäck, M.Sc. in Engineering Physics, employed at Westinghouse Electric Sweden AB and there responsible for BWR fuel material, make the following declaration concerning tests made of alloys for use in nuclear energy plants.

The tests were performed by Westinghouse Electric Corporation, USA, in cooperation with Westinghouse Electric Sweden AB.

The corrosion performance of alloys of the type  $Zr_xNb_ySn_zFe$  (Zr alloy with x, y and z wt% Nb, Sn and Fe, respectively.) in different environments has very recently been presented by one of the inventors behind the current patent application along with five co-authors [1]. The studied material types are presented in Table 1.

The corrosion performance was evaluated by autoclave tests that were conducted in a manner consistent with ASTM Practice for Aqueous Corrosion Testing of Samples of Zirconium and Zirconium Alloys (G2). Exposures in 633 K water were performed at saturation pressure while exposures at 700 K steam were performed at 10.3 MPa. Testing at 633 K included both pure water and lithiated water containing 70 ppm Li that was added as lithium hydroxide. The autoclave tests were periodically interrupted to obtain corrosion weight gains of the specimens. Testing included three specimens per alloy, and the reported corrosion data represent the average specimen weight gains. The corrosion test results in steam at 700 K, pure water at 633 K and 70 ppm lithiated water at 633K are depicted in Figs. 1-3, respectively.

The corrosion behavior in steam at 700 K and pure water at 633 K was quantified by calculating the post transition corrosion rate for each alloy composition by performing a linear least squares fit of the data. The rates were calculated over the time interval of 140 to 469 days for 633 K water and 61 to 251 days for 700 K steam. Also included for comparisons in the corrosion evaluations are results from two Zr-Nb binary alloy samples that were previously reported [2].

The effect of chemistry on corrosion behavior was examined by assessing the impact of the chemistry variations on corrosion rates. Corrosion rates were plotted as a function of individual alloying elements in order to identify potential relationships between alloy chemistry and corrosion behavior. Figure 4 shows the relationship between normalized corrosion rates in 633 K water and 700 K steam as a function of three chemistry variables (Nb, Sn, and Fe). The rates were normalized relative to those of an alloy with a nominal chemistry of Zr-1Nb-1Sn-0.1Fe.

Figure 4a shows the impact of tin on the corrosion rate. Even with variations of other alloying elements, the impact of tin on the corrosion rate in the two environments is apparent. In both pure water and steam environments, the corrosion rate decreases with decreasing tin content. The rate of change in the autoclave tests is about a 5% decrease in corrosion rate for each 0.1% decrease in tin. Figures 4b and 4c show the relative corrosion rates plotted as functions of the niobium and iron contents, respectively. Figure 4b shows that there is no significant correlation with niobium variations. Likewise Figure 4c shows that the effects of variation in iron content on corrosion rates in these environments are secondary in comparison to the tin effects.

Figure 3 is a plot of corrosion weight gains of the various alloys in 70 ppm lithiated water at 633K. In the lithiated water environment, the corrosion rate is only slightly affected by the tin content until it is below a threshold tin value. This suggests that a minimum critical tin content is needed to prevent accelerated corrosion in the lithiated water environment. While the tin content was not studied as an entirely independent variable, non-linear multiple regression analysis was utilized to evaluate the impact of the main alloying elements on the uniform corrosion rate in lithiated water. The result of this analysis indicates that tin is clearly an important factor in the resistance to accelerated corrosion in high lithium environments.

In addition to the beneficial impact of tin on the uniform corrosion rate in the lithiated environment, there is also indication that iron may provide a similar effect. A comparison of two alloys, Zr1.0Nb0.3Sn0.1Fe and Zr1.0Nb0.3Sn0.4Fe, shows iron also contribute to the delay of the accelerated corrosion in high lithium environment. Figure 5 is a plot of relative corrosion rates in 70 ppm lithiated water as a function of the combined iron and tin levels. The results indicate that a combination tin and iron in the alloy provides resistance to accelerated corrosion from 70 ppm lithiated water autoclave tests. It was suspected that the individual effects of tin and iron on lithium accelerated corrosion are not totally equivalent but the initial comparison as shown in Figure 5 indicates the effects of both tin and iron.

In-reactor corrosion is a complex phenomenon and the 70 ppm Li environment is used to simulate the Li accelerated corrosion that might occur in the upper spans of high power fuel assemblies, which may experience concentrated lithium conditions in the oxide due to sub-cooled boiling at the cladding surface. A second possible Li concentration mechanism is boiling in crud on the rod surface. With recent utilities' desire to operate at higher coolant lithium concentrations to control coolant pH and reduce crud formation, lithium corrosion resistant alloys are an important part of robust fuel designs.

It is, finally, concluded that the results from the various tests and analyses strongly support the invention described in the current patent application. The proposed chemical composition provides a material with very good corrosion resistance in all of the studied environments. In addition, the presence of tin at a well optimized level, as the one put forward in the patent application, helps to maintain good mechanical strength, primarily creep and tensile strengths.

Table 1: Nominal alloy chemistry.

Alloy ID	Alloy Elements Composition (wt%)		
	Nb	Sn	Fe
Group 1 (variable tin)			
1-1	1.0	1.3	0.1
1-2	1.0	1.0	0.1
1-3	1.0	0.7	0.1
1-4	1.0	0.3	0.1
Group 2 (high iron, variable tin)			
2-1	1.0	1.2	0.4
2-2	1.0	0.7	0.4
2-3	1.0	0.3	0.4
Group 3 (high niobium, high iron, low tin)			
3-1	1.5	0.5	0.3
3-2	2.0	0.3	0.2

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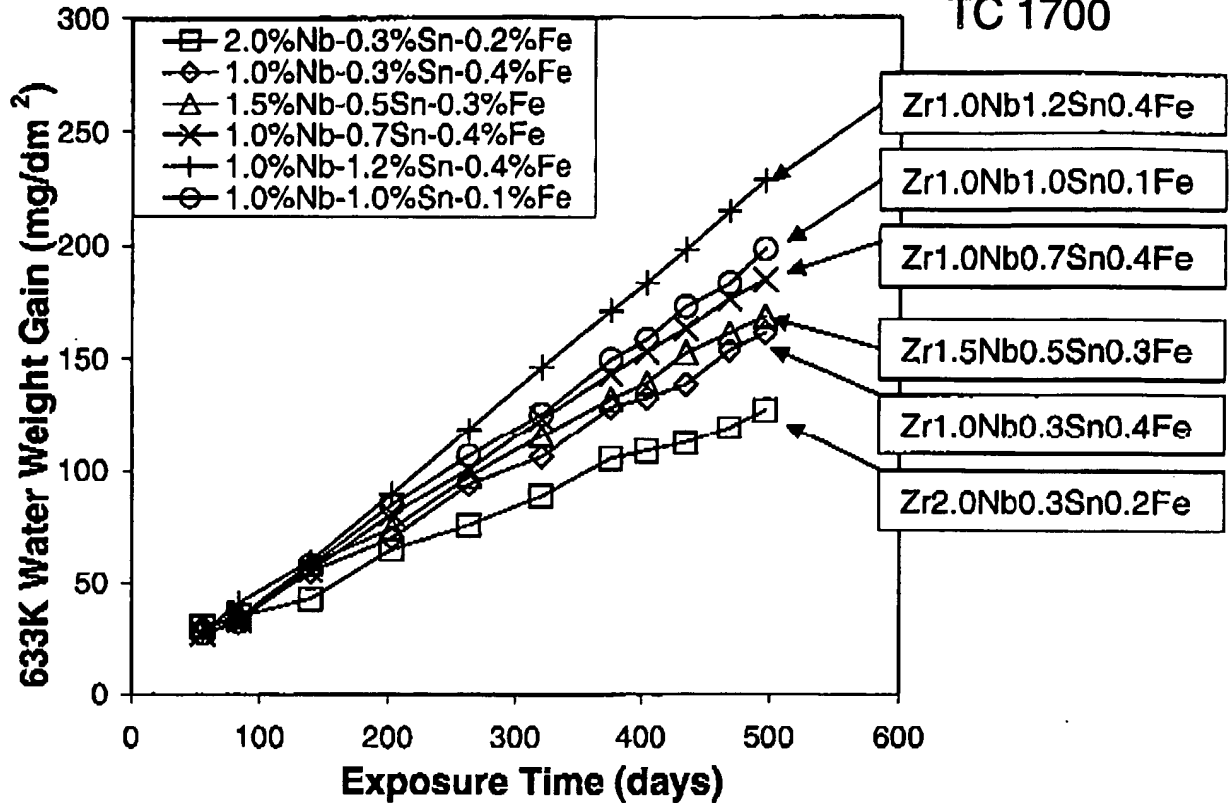


Figure 1: Long term autoclave test results of coupons in steam at 700 K.

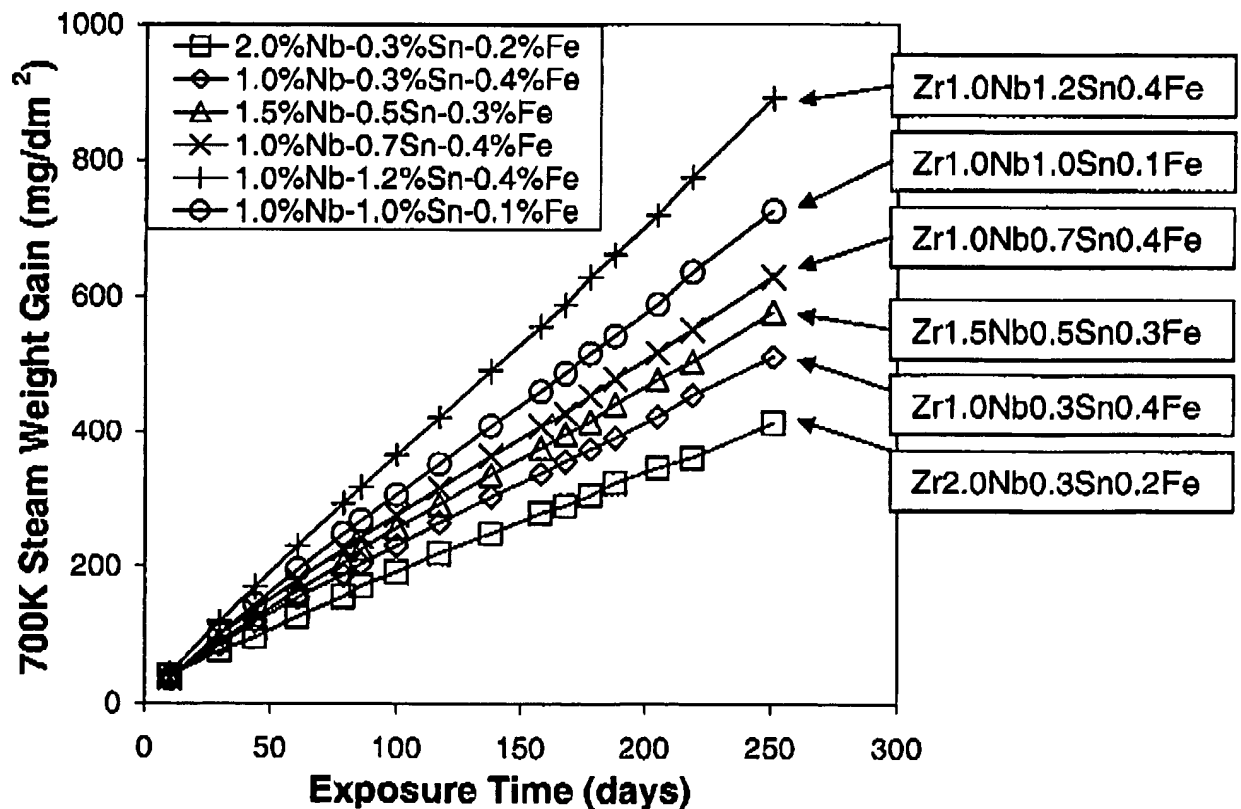


Figure 2: Long term autoclave test results of coupons in pure water at 633 K.

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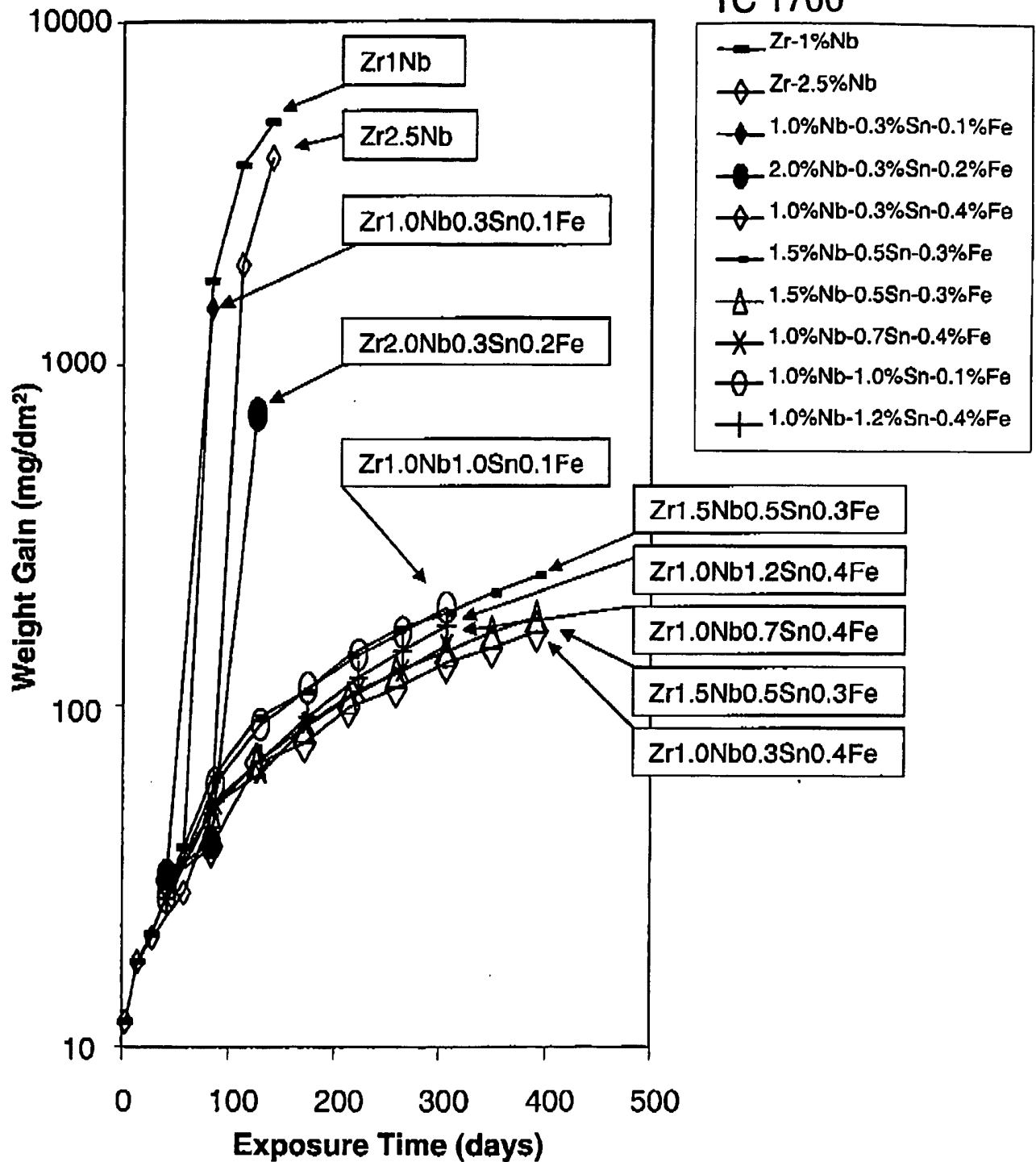


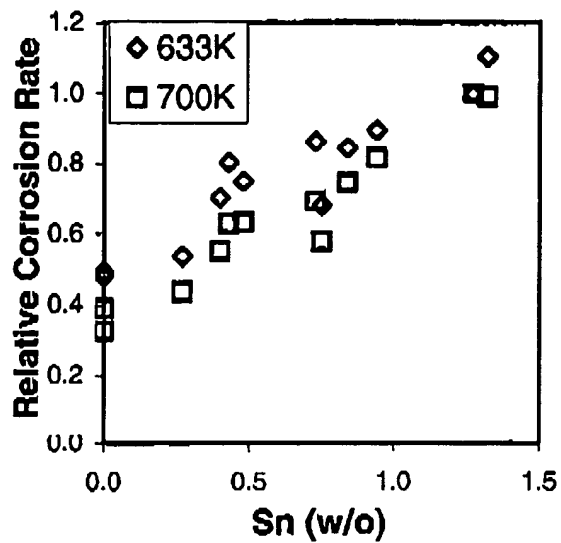
Figure 3: Long term autoclave test results of coupons in 70 ppm lithiated water at 633 K.



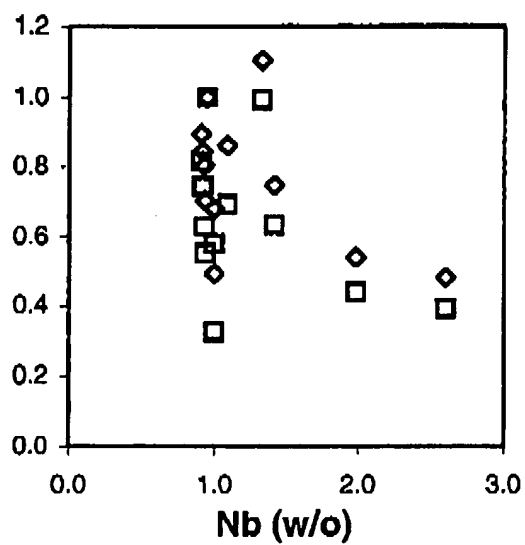
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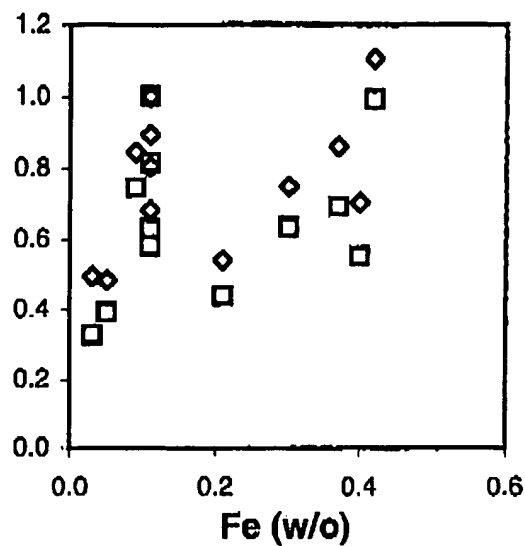
a)



b)



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c)

Figure 4: Variation in normalized (to 1%Sn-1%Nb-0.1%Fe) corrosion rate as a function of chemistry variable: a) tin, b) niobium, and c) iron.

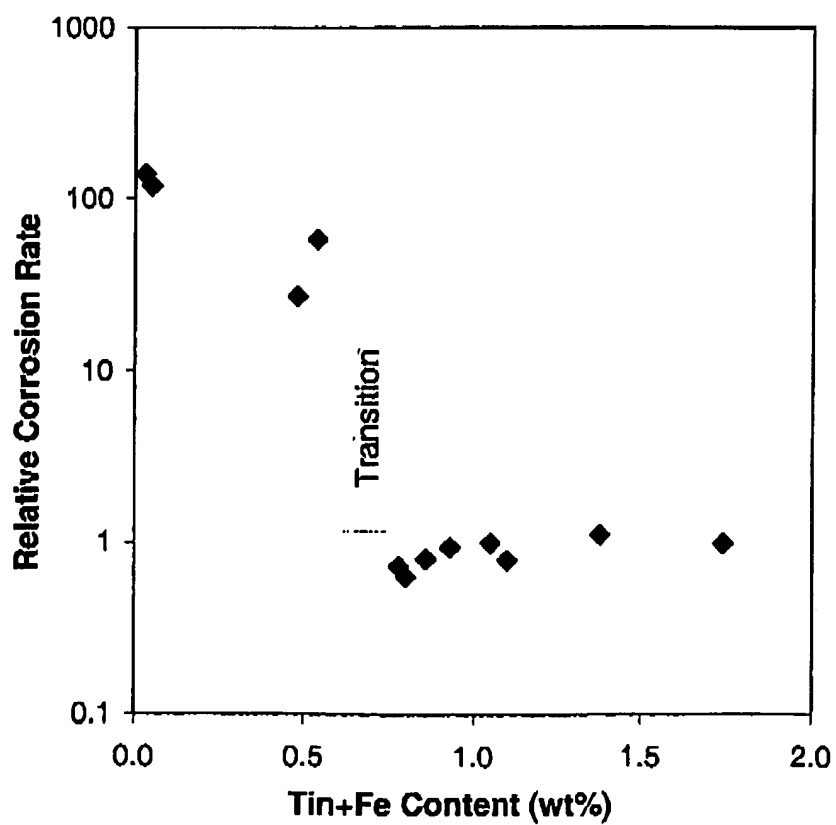


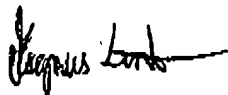
Figure 5: Impact of tin and iron content on corrosion rate in 633K-70 ppm lithiated water environment.

## References

- [1] H.K. Yueh, R.L. Kesterson, R.J. Comstock, D.J. Colburn, M. Dahlbäck and L. Hallstadius, "Improved ZIRLO™ Cladding Performance through Chemistry and Process Modifications", Paper presented at the ASTM 14<sup>th</sup> International Symposium on Zirconium in the Nuclear Industry, Stockholm, Sweden, June 13-17, 2004.
- [2] R.J. Comstock, G. Schoenberger and G.P. Sabol, "Influence of Processing Variables and Alloy Chemistry on the Corrosion Behavior of ZIRLO Nuclear Fuel Cladding", ASTM STP 1295, 1996, P710.

I declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

Västerås, Sweden, 22 June 2004



Magnus Limbäck